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# REVISION

OF THE

# GENUS PINUS,

*AND DESCRIPTION OF*

# *PINUS ELLIOTTII.*

By DR. GEORGE ENGELMANN.

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# *Revision of the Genus* Pinus, *and Description of* Pinus Elliottii.

By Dr. George Engelmann.

No difficulty exists in the circumscription of the genus *Pinus;* floral unite with vegetative characters to establish it so firmly and so plainly, that nobody fails to recognize the species belonging to it. But when we come to analyze and to group the 60 or 70 species of pines which are known to us, we find that they appear so similar, that all attempts to arrange them satisfactorily have failed. The most obvious distinctive character was found in the number of leaves in each bundle, and thus the sections of 2-leaved, 3-leaved and 5-leaved pines were the only ones known to the older botanists. Spach (Syst. veg. 1834) separated *Cembra* on account of its "wingless" seeds; Link (Linnæa, 1841) relied on the number of leaves only, adding two sections, one with 2 or 3, the other with 3 or 4 leaves in a sheath; Endlicher (Synopsis, 1847) was the first to point out the form of the cone-scales as an important character, and his first two sections *Cembra* and *Strobus*, were by the form of this scale distinguished from the other Pines; he retained the character of the "large wingless" seeds, to separate by it *Cembra* from *Strobus*, and *Pinea* from the other two-leaved pines which constituted his section *Pinaster*. Later writers did not add anything to our knowledge of the systematic relations of pines: Carrière (Conifères, 1855) copied Endlicher, and Gordon (Pinetum, 1858) went back to the mere number of leaves to characterize the sections. Ten years later Parlatore (DeCand. Prod. 16², 1868) followed Endlicher in adopting the differences in the form of cone-scales as the most valuable character, and advanced a step further by discarding the proportionate size of the seeds as of sectional value. He divided his subgenus *Pinus* in two sections, *Pinea* with pyramidate and *Cembra* with dimidiate apophyses. The subsections of his *Pinea* were again based on the number of leaves, in twos, in threes, or in fives in each bundle; those with single leaves, with 2 or 3, and those with 3, 4 or 5 leaves had to find their place as best they could.

Not satisfied with such superficial knowledge of this interesting and important genus of trees, I have for a number of years devoted my leisure hours to the careful study of the different species accessible to me. In the following pages I give the principal results of my investigations.

SIZE. Almost all the pine species grow up to be trees; the only shrubby one known to me is *Pinus montana*, heretofore known as *P. Pumilio;* a few make small, insignificant trees, such as *P. tuberculata;* the nut-pines, or cembroid pines, never grow large, but several others attain the greatest dimensions; *P. Lambertiana* grows to the height of 300 feet, with 20 feet in diameter, and *P. ponderosa* (at least in California) comes very near it; these two are probably the largest pines known.

The AGE of pines varies between 15 to 25 years (*P. tuberculata* and perhaps *P. montana*), 300 years (*P. mitis*, *P. ponderosa*, *P. Balfouriana*), and 500 to 600 years (observed in *P. monticola* and *P. Lambertiana*).

The BARK in some species is thin, only a few lines thick, flaky and detached in scales (*P. contorta*, *P. resinosa*); in others (e.g. *P. ponderosa*) it is several inches thick, persistent, rough, and deeply cracked. It is gray in some species, e.g. in the nut-pines, but most commonly of a brown red or cinnamon color, or sometimes deeper brown; in *P. australis* and *P. Elliottii*, especially in the latter, it is laminated, the external layers peeling off in thin plates.

The WOOD grows rapidly, especially during the first (often the first 50) years of their age, so that annual rings are sometimes 2 or 3 lines thick; in *P. glabra* I have seen them even 6, in *P. insignis* 5 and in *P. rigida* var. *serotina* 4 lines thick; in old age or in the short seasons of high altitudes the wood grows so slow that sometimes ten annual rings make not more than the thickness of one line.

The sapwood is always white, and it takes many years before it turns into perfect or heartwood: in *P. ponderosa*, *Lambertiana*, and *mitis* sometimes 100 or even 150 years; in others, e.g. *P. flexilis* and *Sabiana* not more than 20 or 30 years; but the majority of pines which I have examined may require 50 or 60 years to mature their heartwood. In many other trees this process takes about 20 or 30 years, in most oaks on an average

about 20 years, in *Catalpa* not more than 2 or 3 years. The thickness of the sapwood in pines is usually 2–4 inches, and rarely under 1 inch; in *P. ponderosa* I have found it sometimes even 10 inches.

The wood cells and especially those more compact ones of the late summer growth, the outer part of the layers, are often strongly impregnated with resin and thereby darker colored, yellowish or brown, and become in thin sections semi-transparent; this is much more the case in those of the section *Pinaster* than of *Strobus*. The former have mostly heavier and harder wood than the latter, though we find exceptions, such as *P. contorta*, which has soft wood similar to that of the white pine or spruce. Spirally marked cells, such as abound in *Pseudotsuga* and in *Taxus*, have not been found in the pines.

The LEAVES, in the wider sense, are of seven different forms: the cotyledonous or seed-leaves, the primary leaves, the ordinary bracts, the secondary leaves, the bracts constituting the sheath of these, the bracts forming the involucrum of the male flowers, and the bracts supporting the carpellary scale.

The COTYLEDONOUS LEAVES form a whorl of 4 to 18 in number, are triangular, flat on the back, keeled above, higher than broad and mostly entire; in *P. Strobus* I find the keel slightly spinulose-dentate. Stomata are found only on the inner and upper sides, as is the case in the cotyledonous leaves of most conifers; those of *Sciadopitys* are, as far as I know, the only ones that have stomata merely on the under and none on the upper side.

The PRIMARY LEAVES succeed the cotyledons on the main axis; in some species (*P. inops*, *P. rigida*, *P. Canariensis*, etc.) they are also found on the sprouts. They are always subulate from a broader base, flat, keeled on both surfaces, always serrulate, even in those species whose secondary leaves are entire (*P. edulis*), with stomata in rows on both surfaces, more on the lower than on the upper face.

The primary leaves not rarely produce in their axils buds with secondary leaves, but they are most generally reduced to BRACTS (*Hochblaetter*) before their axils become productive. These bracts are triangular-lanceolate, membranaceous or coriaceous,

entire or mostly fringed on the edges, more or less persistent or mostly deciduous, sometimes articulated above their base.

The SECONDARY LEAVES constitute the foliage of the tree: they are borne on an undeveloped branchlet in the axils of primary leaves or mostly of bracts, and are surrounded at base by a sheath of bud-scales (*Nieder blaetter*). These consist of 2 short, rigid, strongly-keeled, lateral bracts, and a number (6–10 or more) of longer, thinner inner ones, which generally are woven together by the delicate fringes of their edges, and are then persistent with the leaves, though in time worn off at the ends; or they are loose, at last spreading and deciduous at the end of the first season. This is the case in all the species of the section *Strobus*, in the nut-pines, and in a few others: *P. Balfouriana*, *Gerardiana*, *Bungeana*, *Chihuahuana*, and usually also in *P. leiophylla*.

The secondary leaves generally occur in definite numbers, 1 to 5, in a bunch, or their number is slightly variable: some species have regularly 2 and 3 leaves (*P. mitis*, *P. Elliottii*), others vary with 3 to 5 leaves (*P. Montezumæ*); species with regularly 3 leaves have occasionally 2 or 4, such with 5 leaves are sometimes found with 6 and even 7 leaves. Where we have one (only in *P. monophylla*), the leaf is terete; where there are two, the leaves are semi-terete, convex on the lower surface and flat on the upper one when fresh, or channelled when dry. Those leaves that grow in bundles of 3 or more are triangular, the upper surface being more or less elevated and keeled; ternate leaves are generally somewhat flatter, and quinate ones higher and regularly triangular. Thus the shape of the leaf and especially its transverse section is mostly sufficient to determine the number in which they occur.

The leaves are in most species minutely but sharply serrulate on the edges, and mostly also on the keel of the upper surface. These serratures are closer together, or more distant, coarser or more delicate, but are absent only in a very few West-American species: the *cembroid* or nut-pines, *P. Balfouriana*, and most forms of *P. flexilis*. The tips of the leaves are generally entire, acute, or acuminate, rarly obtusish; but in all the species of the section *Strobus* they are in the young and fresh leaves finely denticulate.

The stomata are usually distributed in longitudinal rows over

both surfaces in the *Pinaster* section; only *P. Balfouriana* has none on the back, and thus approaches *Strobus* in this as it does in many other respects. In *Strobus* we find on the back no or but few stomata, or sometimes a single or an interrupted line of them. *P. Lambertiana* only has numerous stomata on the back, thus approaching *Pinaster*.

I will have to dwell somewhat extensively on the internal structure of the leaves, as it proves to be of the greatest importance for the classification of the species. We distinguish in a transverse section the thick epidermis, the chlorophyll-bearing parenchyma cells, and in the centre the fibro-vascular bundle. This latter is single in the terete and mostly in the quinate leaves; it is double in the broader triangular or ternate, and in the semi-terete or binate leaves. This difference, however, is of very little diagnostic importance, as we find occasionally single or double bundles in the same species. The fibro-vascular bundles always show wood cells on the upper or ventral, and bast cells on the lower or dorsal side, traversed by delicate medullary rays, usually obliquely diverging from the lower to the upper side. The bundles are imbedded in a mass of small (medullary?) cells, free of chlorophyll, and are together with those surrounded and separated from the parenchyma by a sheath of larger cells, also destitute of chlorophyll.

Within the parenchyma of the leaf a smaller or larger number of longitudinal tubes or ducts are found, the RESIN DUCTS, normally probably two, but very often more, even as many as a dozen or more. These ducts occupy a certain definite position within the leaf. They lie (1) close to the epidermis, *peripheral ducts*, in some species more on the ventral, in others more on the dorsal side of the leaf; or (2) they occupy a place within the parenchyma and surrrounded by it on all sides, *parenchymatous ducts;* or (3) they lie close to the sheath which surrounds the vascular bundles, *internal ducts*. This position of the ducts is so constant, and seems to be so intimately connected with the essential character of the plant, that I venture to adopt it as one of the principal characters for the subdivision of the genus. I must add, however, that in some few species smaller, accessory ducts do sometimes occupy an abnormal position. Thus I find occasionally in some *Strobi*, especially in *P. excelsa*, where there

are mostly two peripheral dorsal ducts, a third upper parenchymatous one; in *P. Bungeana*, which generally has numerous peripheral ducts all around, occasionally a single lateral parenchymatous duct is observed; *P. Canariensis* has regularly parenchymatous ducts, but sometimes they are connected with the epidermis by a very thick bundle of strengthening cells (of which presently); *P. Laricio* has normally parenchymatous ducts, but in a specimen of var. *Pyrenaica* from the Pyrenees in Herb. Cosson I find them sometimes almost touching the epidermis cells, and therefore easily mistaken for peripheral. In *P. rigida* and *Tæda*, and also in *P. pungens* and *filifolia*, which all have normally parenchymatous ducts, I occasionally have observed a number of smaller accessory ducts close to the sheath of the vessels. In pines with very slender leaves it is sometimes difficult to discover the ducts, and in some forms they are, I believe, really absent, especially in cultivated specimens. Such may give us some trouble in their classification.

A peculiar element in the structure of the pine leaves are certain cells which had been formerly named "hypoderm cells"; but as they also occur in other parts of the leaf apart from the epidermis, they more appropriately receive the name of STRENGTHENING CELLS. They are thick-walled, elongated, colorless cells, much larger than the bast and wood cells, generally of the diameter of the epidermis cells, rarely a little larger, often smaller, and always smaller than the cells of the parenchyma. They give to the leaf its rigidity, and are most abundant in the most rigid pine leaves; in the softer more flaccid ones they are almost entirely wanting. Thus they are scarce or entirely absent in some species of the *Strobus* section; in *P. Pseudostrobus* and *P. filifolia* they are very imperfectly developed. The strengthening cells are principally found under and close to the epidermis (whence the name hypoderm cells) either in a continuous layer or mostly in bundles, interrupted by the lines of stomata; they are generally most abundant within the angles of the leaves. Sometimes they surround the ducts, and in all the species allied to *P. resinosa* and *P. sylvestris* they are found only there, and not or scarcely at any other places. In some species these cells also occur within the sheath, above and below the fibro-vascular bundles. Their presence and position is not absolutely constant, but

may be relied on to some extent for diagnostic purposes. Thus the quinate smooth-edged leaves of *P. flexilis* and *P. Balfouriana*, which would be difficult to distinguish without their cones, may be readily recognized by the strengthening cells, which in the latter surround the more closely approximating ducts, while in the former the ducts, widely apart from one another, are destitute of these cells.

The PERSISTENCE of the leaves is very different in different species; in *P. Strobus* and others they fall in the autumn of the second year; more commonly they last to the end of the third year; in some species, e.g. *P. Banksiana*, they do not fall before they are 4, 5 or even 6 years old; in *P. Balfouriana*, or at least in var. *aristata*, I have seen them persist 12 to 14 years. When the leaves persist only a short time and are long, and the annual growth of the axis is short, they form brushes or tassels (*P. australis*) at the end of the branchlets, but where they are short and persist long (*P. Balfouriana*) they give the branchlets that "fox-tail or bottle-brush" appearance of which travellers speak. In young and vigorous trees the leaves are apt to persist longer than in old ones.

In exceptional cases and as a monstrosity the leaf-bundles become proliferous, the branchlet which bears the secondary leaves elongating and forming a regular branch.

The pines are monœcious trees which bear their male and female flowers generally on different branchlets, the male commonly on the lower, the female frequently on the upper part of the tree; sometimes both are found on the same axis, the male below, the female above.

The MALE FLOWERS are borne on the lowest part of the year's shoot, in the axil of bracts, either crowded together in a kind of a head or elongated in a spike; the axis usually continues to elongate during or after flowering and makes a leafy branch, which in its continuation in succeeding years often again bears flowers. Male flowers sometimes abnormally make their appearance higher up on the axis mixed with leaf-bundles and occupying the place of such. The male flowers consist of an indefinite number of anthers sessile on a more or less elongated column, and have the form of an oval or a cylindrical ament, for which they used to be taken. They are surrounded by a somewhat defi-

nite number of bracts, which assume the functions of a calyx and have been sometimes designated as such. Linnæus, in his Syst. Nat. ed. 1, speaks of a *calyx 4-phyllus*. Their number varies in the different species from 3 to 15 or 16, but is fairly constant in the same species. The two exterior lateral bracts are strongly keeled, like those of the sheath of the leaves, and stouter and mostly shorter than the others; the third is placed on the upper side, towards the axis of the inflorescence; the fourth on the lower or dorsal side, opposite the supporting bract, and so forth. The innermost ones not rarely exhibit a transition to the anthers, bearing small or incomplete anther cells on the lower part of their back. In *P. resinosa* and *Canariensis* I find the involucral bracts articulated in the middle.

A table exhibiting the numerical proportion of involucral bracts in the different species, the male flowers of which I could examine, may not be without value.

3 or 4 involucral bracts I find in *P. sylvestris* and *Pinaster;*
3 to 6 in *P. densiflora;*
4 in *P. Balfouriana*, *Canariensis*, and *Greggii;*
4 to 5 in *P. edulis* and *Parryana;*
4 to 6 in *P. Pinea* and *P. Halepensis;*
4 to 10 in *P. Pyrenaica;*
5 to 6 in *P. monophylla;*
6 in *P. leiophylla*, *Laricio*, and *contorta;*
6 to 7 in *P. resinosa*, *montana*, and *Massoniana;*
6 to 8 in *P. Strobus*. *excelsa*, *Peuce*, *Cembra*, *rigida*, *tuberculata*, *muricata*, *pungens*, *Banksiana;*
8 to 10 in *P. monticola*, *flexilis*, *insularis*, *Chihuahuana*, *Thunbergii*, *Laricio* var. *Pyrenaica*, and *Austriaca*, *Coulteri*, *inops;*
8 to 12 in *P. Tæda;*
9 to 12 in *P. Montezumæ* and *mitis;*
10 in *P. insignis;*
10 to 12 in *P. ponderosa;*
10 to 15 in *P. Sabiniana;*
12 in *P. Merkusii* and *Elliotti;*
12 to 14 in *P. Khasia*, *glabra*. and *australis;*
14 to 16 in *P. Lambertiana* and *Cubensis*.

The ANTHERS consist of two parallel extrorse cells, which open longitudinally on their back; their connective, heretofore often called a bract, spreads out into a transverse semi-orbicular or almost orbicular, entire or denticulate (in most species of *Pin-*

*aster*) or lacerate (*P. Lambertiana*) crest, or it terminates in a knob or a few teeth (in most *Strobi* and a few *Pinasters* such as *P. Balfouriana* and *sylvestris*).

The POLLEN has the well known bilobed form, consisting of an elliptic central portion, which emits the pollen tubes, and two lateral sacs which are said to contain air. The longer diameter measures 0.025 to 0.045 lines, mostly between 0.030 and 0.040 lines, while the pollen grains of *Abies* and *Picea* are much larger and in many instances twice as large, viz. 0.045 to 0.070 lines long. Thus by the pollen alone *Pinus* can generally be distinguished from those allied genera. The different species of pines are pretty constant in the size of their pollen.

Without going into minute detail, I will only state that I find pollen grains of

0.025–0.030 lines in *P. edulis* and *P. Banksiana*;
0.030–0.035 " in *P. Balfouriana, sylvestris, montana, resinosa, Chihuahuana, Laricio, inops, contorta;*
0.035–0.040 " in *P. Strobus, excelsa, Pinea, rigida, Tæda, mitis;*
0.040–0.045 " in *P. Lambertiana, flexilis, Montezumæ, Pinaster, ponderosa, Sabiniana, Elliottii.*

The property of the pine-pollen to float for a long time in the air, and to be carried by storms to very distant localities, is well known. I have found in streets of St. Louis after a rainstorm from the south, in March when no pines north of Louisiana were in bloom, pine-pollen which must have come from the forests of *P. australis* on Red river, a distance of about 6½ degrees of latitude or 400 miles in a direct line.

The FEMALE FLOWER consists, as in all *Abietineæ*, of a carpellary scale in the axil of a smaller, concealed, bract, bearing two pendulous ovules on the lower part of the upper side. A number of such scales in the axils of their supporting bracts, and spirally arranged, form the female ament. The question of the nature of the scales, and of the ovules they bear, is not to be discussed here, but it may be stated that the best lights force the view on us that the carpellary scale consists morphologically of two leaf-organs, lateral to an undeveloped axis and united at their posterior edges (those turned towards the axis of the ament), and thus bearing their naked ovules on their morphologically outer but now reversed and *apparently* upper side.

The carpellary scales, which in the flower as well as in the fruit we call, in short, *scales*, are either rounded, obtuse, and appressed (in *Strobus*, etc.), or they have a short (*P. resinosa*, *sylvestris*, etc.) or a longer (*P. ponderosa*, *Taeda*) or an elongated subulate, often squarrose, point (*P. contorta*, *inops*, *pungens*).

The aments are globose, oval or elongated, subsessile or pedunculed, single or several together, always erect, each borne in the axil of a bract, its base invested by sterile bracts which gradually or suddenly give place to the carpel-bearing bracts, just as the involucral scales of the male flowers give place to stamens. They make their appearance on the upper part of the year's shoot, often just below the terminal bud, when we call them *subterminal;* or they become *lateral*, when the axis elongates beyond them, and sometimes more aments form above them in the same season. The axis above the aments continues covered with leaf-bundles in some, while in others it is naked for some distance, or rather destitute of leaves, bearing only bracts; a second stage of aments or the terminal bud is always preceded by a number of leaf-bundles.

The position of the female ament, whether subterminal or lateral, seems to be connected with an essential difference in the species of pines, secondary in importance only to the leaf structure as described above, and both of these together will enable us to arrange the species in something like a natural order. It ought to be understood, however, that the relative position of the ament on the axis is not absolute and that variations do occur. Species with ordinarily subterminal aments may in young and vigorous shoots sometimes bear lateral aments; this occurs, though very rarely, in *P. ponderosa* and *australis*, and perhaps in others, but I have never seen it in any of the *Strobus* section, nor in *P. sylvestris*, *resinosa*, *Laricio* or its allies. More frequently subterminal aments are found in species which normally bear lateral ones, probably when with the formation of the aments the vigor of the axial growth has been exhausted; thus sometimes a second stage of aments is subterminal, while the first is of course lateral; or subterminal and lateral ones are occasionally found on different branches of the same tree; or, very rarely, a tree bears almost entirely subterminal aments. This last case I have seen in

the Californian *P. muricata* and in the Mediterranean *P. Pyrenaica*. This character has to be studied intelligently among the native trees in their homes. So long as only a few herbarium specimens can be consulted it must remain doubtful, and errors may creep in, especially as collectors have heretofore paid so little attention to the necessity of obtaining instructive specimens, which, however, are easily procured in any season of the year, provided the tree bears at all; for always either flowers or young cones, or in spring both together, can be obtained.

The compound FRUIT resulting from these aments, known as the *cone* or *strobile*, matures at the end of the second, or in a single species, *P. Pinea*, of the third season; during the first twelve months it does not enlarge much; in most species it retains its erect position during that period, but in a few it becomes reversed soon after flowering and before the leaves are developed (*P. sylvestris* and *Elliottii*); in the allies of *P. Strobus* the slender peduncle bends downwards in the second summer apparently by the weight of the swelling cone; but in the majority of the species the cones in that period assume a horizontal or somewhat declined, rarely a strictly recurved, position. Only in *P. Banksiana* it is as often curved upwards as horizontal. We continue to speak of subterminal and of lateral cones in regard to that part of the axis which bore the flowers, though the branch elongates in the next year, and the maturing cone, strictly speaking, thus always becomes lateral.

The cones are, as the name might indicate, conical, from subglobose to oval or subcylindrical, mostly more or less symmetrical, often slightly oblique, and in some Californian and Mexican species (*P. insignis*, *tuberculata*, *muricata*, *patula*) so much so, that the scales on the inner and the outer side become very unequal; in the first named species especially we find the scales on the outer, convex, side much larger and tumid; on the inner, more flat, side smaller and depressed, but singularly enough more fertile than the big outer ones. The color of the cones is from gray to light leather-brown, reddish, or deep brown, with a dull or a glossy or almost varnished surface. They vary in length from 1½ or 2 to 12 or even, in *P. Lambertiana*, to 18 inches.

The phyllotactic arrangement of the scales is quite interesting,

but not of much diagnostic importance: nevertheless it will be necessary in the description of the different species to mention it, and also to state the number of the more prominent secondary spirals, two of which, inclining in opposite directions, are always the most conspicuous. The long cones of *P. Strobus*, *excelsa* and *Ayacahuite*, and the short ones of *P. edulis* and *monophylla*, show the $\frac{8}{1}\frac{}{3}$ order of scales, and the 3 and 5 spirals are the most prominent ones. *P. Lambertiana* and *Sabiniana* have the $\frac{3}{5}\frac{}{}$ arrangement with the 8 and 13 or the 13 and 21 spirals most conspicuous. The intermediate orders of $\frac{1}{2}\frac{3}{1}$ and $\frac{2}{3}\frac{1}{4}$ are the most common ones: **abnormal orders are extremely rare.**

The cone scales furnish us the most valuable characters for the classification of the species. Their exposed part, not covered by adjoining scales and more or less thickened, has been called the *apophysis*; it is rather depressed and terminates in a blunt point in the section *Strobus*; in *Pinaster* it bears its point on the usually more thickened back, the *umbo*, mostly armed with a prickle, weak or strong, early deciduous (in *P. Balfouriana*, *insignis*, *Banksiana*) or stout and persistent (in *P. rigida*, *Taeda*, *inops*, *pungens*); in some species (*P. Sabiniana*, *Coulteri*) it becomes a thick, long, **and often curved or twisted spur.**

The bracts which support the scales remain concealed, but become greatly enlarged and mostly thickened and corky, and help to form lodges for the seeds, which are enclosed between them and the scales.

The cones generally open their scales soon after maturity, drop their seeds, and fall off soon afterwards; in most cases they separate at the insertion of the peduncle, but in a few instances (*P. ponderosa*, *P. australis*) the peduncle and the lowest part of the axis together with a number of scales remain on the branch. In some species (*P. Sabiniana*, *Coulteri*) the open cones persist for several years on the tree, and in others they remain almost indefinitely, so that they are apt at last to be partially enclosed in later layers of wood. Such are *P. Banksiana*, *inops*, *pungens*, *insignis*, *muricata*, *rigida*, and some Mexican species. Most specimens of *Pinus contorta* retain their cones in this manner, while those of the higher sierras of California are early deciduous, proving that this character is not of great specific importance. The persistence of the cones may be connected with the

peculiarity of some species to retain their seeds in temporarily or permanently closed cones, when they are called *serotinous*. Such are southern forms of *P. rigida* (var. *serotina*) and *P. inops* (var. *clausa*), rarely *P. Taeda*; in some Californian (*P. insignis*, *tuberculata*, *muricata*) and Mexican species (*P. patula*, *Teocote* and *Greggii*) this is still more conspicuous. The seeds of such serotinous cones seem to retain their germinating power for many years longer than loose pine seeds, which are known soon to lose their vitality.*

The SEEDS are obovate, or often more or less obliquely triangular, rarely (in *P. Sabiniana* and *Gerardiana*) nearly cylindrical, generally somewhat compressed, 2 to 12 lines in length, smooth or often on the lower surface ridged or slightly tuberculated, always destitute of balsam vesicles, pale gray or yellowish, or spotted, or brown, and often black. A wing is always present, and is generally several times longer than the seed; in some large-seeded species (*P. flexilis*, *Cembra*, *edulis* and the other nut-pines, and *Pinea*) it is reduced to a narrow rim, which is apt to remain attached to the scale when the seed is liberated; in *P. parviflora*, *Bungeana*, *Gerardiana*, *Torreyana*, and *Sabiniana*, it is more conspicuous, but shorter than the seed itself; in *P. Coulteri* it is about as long as the seed, and in *P. Lambertiana* longer. The size of the seed and the proportion of the wing to it has been considered to furnish valuable sectional characters, but it proves to be only of specific importance. The wing is always more or less oblique and widest in some species upwards, in others near the base. The base of the wing forms a rim which surrounds the seed, leaving its under side free and with its edge covering part of, or rarely the greater part (*P. Elliottii*) or the entire upper side (only seen in *P. Banksiana*). Generally the wing and its rim is completely separable from the mature seed, but in a few species (*P. Strobus* and allies) it adheres to it closely, and is at last broken off irregularly.

The COTYLEDONS, 4 or 5 to 15 or 18 in number, are mostly several times shorter than the caulicle, usually not longer than its

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* Seeds from closed cones of *P. contorta*, two to eight years old when I collected them in Colorado, and then kept four years in a hot garret, germinated freely with Prof. Sargent of the Arnold Arboretum, Mass.

diameter, and rarely as long or a little longer than it ; this seems to be the case especially where the leaves also are of unusual length, e.g. in *P. australis.*

It is easy enough and very satisfactory to ascertain the number of cotyledons where a large quantity of seedling pines is at one's disposal. With me this was unfortunately not the case : hence I had to examine the seeds themselves, quite a laborious process, rarely extending over more than six or eight specimens, and often less. In examining greater numbers more variation will probably be discovered. As it is, the different species show a tolerable constancy in the number of their cotyledons. I give here only the result of my own observations. leaving out those found in the books. I have observed

about 5 cotyledons in *P. Balfouriana*, *montana* (3-6), *Laricio*, *rigida*, *inops* (4-6), *muricata* (4-5), *glabra* (5-6), *Banksiana* (4-5);

about 6 cotyledons in *P. Balfour.* var. *aristata* (6-8), *resinosa* (6-7), *sylvestris* (6-8), *insignis* (5-8), *tuberculata* (5-8), *Tæda* (5-8), ***pungens*** (7), ***Pinaster*** (5-8), ***mitis*** (4-7);

about 8 cotyledons in *P. Strobus* (7-11), *monticola* (6-9), *parviflora* (8-10), *flexilis* (8-9), *monophylla* (7-10), *edulis* (7-10), *Parryana*, *Halepensis* (6-9), *ponderosa* (6-11), *Canariensis*, *australis* (7-10), ***Elliottii*** (6-9);

about 10 cotyledons in *P. excelsa* (8-12), *Peuce* (9-10), *Cembra* (9-12), ***cembroides*** (9-12), ***Bungeana*** (11);

about 12-15 cotyledons in *P. Ayacahuite* (12-14), *Lambertiana* (12-15), *Pinea* (10-14), *Torreyana* (13-14), *Sabiniana* (12-18), ***Coulteri*** (10-14).

In germination the seed-shell is raised like a hood on the tip of the cotyledons, mostly after the wing has come off, but sometimes the wing is raised high above the plantlet (*P. australis*). The axis generally soon elongates, bearing the primary leaves, but the species just mentioned behaves peculiarly in this period, almost as do many moncotoyledonous trees. For six or eight years it grows not in length but only in thickness, and bears in the axils of the short primary leaves numerous tufts of long and slender secondary leaves, which give the plantlet the appearance of a coarse grass or a rush ; only after it has acquired sufficient vigor the thick axis rapidly shoots up.

I now propose an arrangement of the species of *Pinus* based upon the more essential characters above analyzed, and, though I by no means claim it to be a faultless one, I expect that it will deserve the character of a natural one as much as any that can be devised. I find with Endlicher the most valuable character in the fruit scale, or rather, to speak more correctly, I find that the form of the fruit scale in this genus corresponds with a series of other characters which constitute two very natural sections of the genus. My section *Strobus* in a wider sense includes his *Strobus* and *Cembra*, and my *Pinaster*, also enlarged, comprises all his other sections, viz. *Pseudo-strobus*, *Taeda*, *Pinaster*, and *Pinea*. The subsections are distinguished by the position of the ducts within the leaf, whether peripheral, parenchymatous, or internal. Subordinate to this character is the subterminal or lateral position of the female ament and the cone. Only after this may the number of leaves in a sheath be taken into consideration, and perhaps the presence or absence of strengthening cells around the ducts. It will be found that thus not only natural but to some extent even geographical alliances are best preserved. I enumerate only such species or subspecies (these in brackets) which I have been able to examine myself; the list, however, will be found nearly complete. The nomenclature of Parlatore in DC. Prod. xvi.[2] is adopted unless otherwise stated.

**Sect. I. STROBUS.** Apophysis with a marginal unarmed umbo, generally thinner; **cones subterminal; leaves in fives, their** sheaths loose and deciduous; anthers terminating in a knob, or a few teeth, or in a short incomplete crest: wood softer, lighter, **less resinous.**

§ 1. EUSTROBI. Ducts peripheral.—Northern or mountain species of the Old and New World.

* Wings longer than the seeds: leaves sharply serrulate, denticulate at tip.

† Strengthening cells few, none around ducts.

*P. Strobus, monticola, excelsa, Peuce,*[1] *parviflora,*[2] *Bonapartea,*[3] *Ayacahuite.*

†† Strengthening cells abundant under the epidermis and surrounding ducts.

*P. Lambertiana.*

** Wings much shorter than seeds; leaves mostly entire, not denticulate at tip.

*P. flexilis,* (*albicaulis,*) *pygmæa.*

§ 2. CEMBRÆ. Ducts parenchymatous; leaves sparingly serrulate, scarcely denticulate at tip.—Europe and principally Asia.

*P. Cembra*,[4] *Mandschurica, Koraiensis.*

**Sect. II. PINASTER.** Apophysis with a dorsal umbo, mostly armed, generally thicker; leaves 1 to 5 in a bundle, their sheaths usually persistent; anthers mostly terminating in a semi-orbicular or almost orbicular crest; wood generally harder, heavier, and more resinous.

**A. Ducts peripheral.**

***a.* Cones subterminal.**

§ 3. INTEGRIFOLIÆ. Leaves smooth-edged, their sheaths deciduous; anthers terminating in a knob or a few teeth.— Western North America and Mexico.

* Cones short subglobose, with thick scales, unarmed; seeds large with a minute wing; leaves 1 to 5. ***Cembroides.***

*P. Parryana*, *cembroides*, *edulis*, *monophylla*.[5]

** Cones oval or elongated, scales armed with a deciduous or persistent prickle or an awn, seeds much shorter than the wing, leaves in fives. ***Balfouriana.***

*P. Balfouriana*,[6] (*aristata*).

§ 4. SYLVESTRES. Leaves serrulate, their sheaths persistent; anthers crested or (only in *P. sylvestris*) merely knobbed.—Europe and Asia, one species in America.

* Leaves in threes; wings much longer than seeds.—East India and its islands. ***Indicæ.***

*P. Khasia*,[7] *insularis*,[7] *longifolia*.[7]

** Leaves in twos; strengthening cells abundant, principally around ducts; fructification biennial, cones and seeds small, wings large. *Eusylvestres*.—Old World, one species in Northeastern America.

*P. sylvestris*,[8] *montana*,[8] *resinosa*,[9] *densiflora*.[10] *Massoniana*,[11] *? Merkusii*.[12]

*** Leaves in twos; strengthening cells under the epidermis and around ducts; fructification triennial, cones and seeds large, wings rudimentary.—A single Mediterranean species.

*P. Pinea.*

***b.* Cones lateral.**

§ 5. HALEPENSES.—Old World.

* Leaves in threes, their sheaths deciduous; umbo very prominent; wings shorter than the large seeds. *Gerardianæ.* Asia.

*P. Gerardiana*,[13] *Bungeana.*

** Leaves in twos, their sheaths persistent; cones smoothish; wings much longer than the seeds. *Euhalepenses.*—Mediterranean regions.

***P Halepensis*,[14] *Pyrenaica*.[15]**

B. Ducts parenchymatous.

*a*. Cones subterminal.

§ 6. PONDEROSÆ.—Mostly American, with three Old World species.

* Leaves in fives, ducts usually free of strengthening cells. *Pseudostrobi*.—Central America and Mexico to Arizona and California.

*P. leiophylla*,[16] *tenuifolia*, *filifolia*,[17] *Pseudo-Strobus*, *Montezumæ*[18] (*Hartwegii*), *Torreyana*,[19] *Arizonica*.[20]

** Leaves in threes, sometimes in fours or fives, their sheaths persistent; strengthening cells under the epidermis, around ducts, and usually also near the fibro-vascular bundles.—*Euponderosæ*.—Northwestern America, Mexico, and Canary Islands.

*P. Engelmanni*.[21] *ponderosa*[22] (*Jeffreyi*), *Canariensis*.[23]

*** Leaves in threes, their sheaths deciduous.—Mexico and Arizona.

*P. Chihuahuana*.[24]

**** Leaves in twos, generally with some strengthening cells around ducts. *Lariciones*.—Europe to Asia and W. America.

*P. Laricio*[25] (*Austriaca*), *Thunbergii*,[26] *contorta*[27] (*Murrayana*).

*b*. Cones lateral.

§ 7. TÆDÆ.—Mostly American, only one Old World species.

* Leaves in threes, ducts mostly without strengthening cells. *Eutædæ*.—North America to Mexico.

*P. Sabiniana*,[28] *Coulteri*,[28] *insignis*,[29] *tuberculata*,[30] *Tæda*,[31] *rigida*[31] (*serotina*[32]), *Greggii*, *Teocote*, *patula*.[33]

** Leaves in twos; cones with very stout prickles. *Pungentes*.

† Ducts without strengthening cells.—North America.

*P. inops* (*clausa*[34]), *pungens*,[35] *muricata*.[36]

†† Ducts surrounded by strengthening cells.—Southern Europe.

*P. Pinaster*.[37]

*** Leaves in twos, or in the first often also in threes; cones with weak or deciduous prickles. *Mites*.—Eastern North America.

*P. mitis*,[38] *glabra*,[39] *Banksiana*.[40]

C. Ducts internal.

§ 8. AUSTRALES. Leaves in twos to fives; timber very heavy and resinous.—Southeastern North America, West Indies, and one species in Mexico.

* Cones subterminal; leaves in threes to fives. *Euaustrales.*

*P. oocarpa,*[41] *occidentalis, australis.*[42]

** Cones lateral or mostly so; leaves in twos to threes. *Elliottiæ.*

*P. Elliottii,*[43] *Cubensis,*[44] *Wrightii.*[45]

## NOTES.

1. *P. Peuce*. Griseb., may after all be distinct from *P. excelsa*; it has much shorter leaves and sheaths, and, if my specimen can be relied on, a short fruiting peduncle: the structure of the leaf is nearly the same in both. *P. Peuce, excelsa*, and *monticola* have a layer of strengthening cells all around under the epidermis, interrupted only by the stomata, and not in distinct bundles as in *Lambertiana* and *Bonapartea*, while *P. Strobus, Ayacahuite*, and *parviflora*, have scarcely any. They all have regularly two dorsal ducts only. In *P. excelsa* I have repeatedly found a third, upper, and always a parenchymatous one.

2. *P. parviflora*, Sieb. & Zucc. A branch in Herb. Haenke in the Prague Museum, marked "*P. heterophylla*. Presl, Nutka Island," seems to belong to this species, which is distinguished by slender, distantly and very slightly serrulate leaves, and scarcely any strengthening cells.

3. *P. Bonapartea*. Roezl. Prof. E. Purkinje, of the Foresters' Academy of Weiswasser, Bohemia, who was probably the first to carefully study the microscopic anatomy of the pine-leaves with a view to the diagnosis of the species, and who is now publishing the results of his investigations in an extensive and copiously illustrated work, has directed my attention to the leaf-structure of this form. It deviates from all the other *Strobi* in having numerous, usually 7, ducts, 3 on the back and 2 on each of the upper sides, and having strengthening cells in numerous bundles all around and especially in the angles. I find no stomata on the back. Roezl's *P. Don Pedri* has exactly the same structure, but has 3 or 4 series of stomata on the back: both evidently belong together. Though I have not been able to study the flowers and fruit, I do not hesitate to pronounce it distinct from *P. Ayacahuite*, which, like *P. Strobus*, has scarcely any strengthening cells, and only 2 dorsal ducts.

4. *P. Cembra*, Lin. The ducts, generally in the middle of the parenchyma, sometimes nearly approach the epidermis, but I have always found them separated from it by at least one layer of parenchymatous cells.

5. *P. monophylla*, Torr. & Frem. The number of ducts is excessively variable; I have found from 3 to 14 in different leaves. The leaves are usually curved, and the upper side, proved to be such by the relative position of the wood and bast cells (see p. 165), is always directed towards the branch. Sometimes two-leaved bundles occur. It is an open question whether the four species of the subsection *Cembroides* may not properly be united into one, as the difference of flowers and fruit is very slight, and that of the foliage only relative.

6. *P. Balfouriana*, Jeffrey, and *P. aristata*, Engelm., of the Colorado Rocky Mountains, are identical in leaf-structure and in flowers and must be united, though the cone of the former is elongated, often even cylindrical, the apophyses thicker and peculiarly spongy, and at maturity unarmed, while the other has an oval cone with thinner scales and awnlike prickles. In Utah and Nevada a form occurs with cones like the latter, but with short, stout, recurved prickles. Parlatore enumerates *aristata*, but does not mention *Balfouriana*.

7. *P. Khasia*, Royle, and its two allies, form a very natural little group. Leaves in this species with 2 dorsal ducts; strengthening cells very slight and only in the corners; male flowers 1 inch long, slender; involucral bracts 12 to 14, exterior half as long as the inner ones, all apparently pointed; anthers ¾ to 1 line long; crest only ½ line wide, nearly entire.

*P. insularis*, Endl., has similar leaves, ducts often indistinct, strengthening cells slight in the corners and some scattered under the epidermis and also near the vessels; male flowers 1 inch long; involucral bracts about 8, outer pair more than half as long as the inner ones; anthers less than 1 line long, crest nearly entire.

*P. longifolia*, Roxb. Ducts few (in Wallich's specimens), or many (in Hooker and Thompson's), or none at all (Hooker's; Thuret's cult.); strengthening cells strongly developed in bundles all around leaf; bracts large, strongly fringed, deciduous; male flowers larger than in last, 1–1¼ inches long, thicker; anthers 1⅓ lines long; crest ¾ line wide, strongly fringe-denticulate; involucre not seen. The thick bundles of strengthening cells and the larger male flowers readily distinguish it from the two others.

8. *P. montana*, Duroi, is so well characterized that it is inconceivable how it could have been taken for a variety of *P. sylvestris*, unless some hybrid forms, which are said to occur, have created the difficulty. The involucral bracts are always more numerous, usually about 6, the anthers crested, the female aments subsessile, and the young cone erect; in *sylvestris* the involucral bracts rarely exceed 3, the crest of the anthers is reduced to a small ridge or a few teeth, the female ament is not longer than its peduncle and becomes recurved soon after flowering.

9. *P. resinosa*, Ait., is the only American representative of this well characterized group. The 6 involucral scales are articulated in the middle, the upper part falling off early (p. 168); ducts almost always only 2 on the upper side of the leaf.

10. *P. densiflora*, Sieb. & Zucc. Leaves with numerous ducts, mostly surrounded by strengthening cells, also some of these within the sheath; in a few instances, in Japanese as well as in cultivated specimens, the strengthening cells are almost wanting; male flowers oval, only 2 to 3 lines long, in an elongated spike; involucrum of 3 or 4 or rarely 5 or 6 bracts of equal length; anthers only ½ line long, or less, with a small, slightly denticulate crest. Only in Japan. Sometimes cultivated under the name of the following.

11. *P. Massoniana*, Lamb. Parlat., well distinguished from the tree thus named by Siebold & Zuccarini and by Endlicher, which was named by Parlatore *P. Thunbergii* (see note 26). It is similar to the last, but has longer and more slender leaves and is a native of the warmer climate of Southern China, and is not hardy where *densiflora* and *Thunbergii* are. Ducts few or many, often with a few strengthening cells, these cells also in the corners, very few under the epidermis, rarely some with the vessels; male flowers slender, cylindric, 6–8 lines long, in a spike, involucrum of 6 or 7 bracts, the outer pair rather shorter than the inner ones. Griffith, No. 4992, from Afghanistan, in Herb. Kew, with 2 ducts on the upper side of the broader leaves, may belong here, which would extend the geographical area of this species.

12. *P. Merkusii*, Jungh. & De Vriese, seems to be closely allied to the last and probably belongs here, or ought perhaps to be considered rather a two-leaved *Indica*. In the poor specimens at my disposal I could not discover any ducts: the leaves are longer and more slender, the strengthening cells similarly disposed. The involucrum consists of 12 bracts, the outer pair not half as long as the inner ones.

13. *P. Gerardiana*, Wallich. Anther crests semi-orbicular, laciniate-dentate, seeds nearly 1 inch long.

14. *P. Halepensis*, Mill. Cones with longer or shorter peduncles, lateral and often low down on the axis, generally single, with flat or sometimes somewhat tumid scales.

15. *P. Pyrenaica*, Lapeyr., fide Parlatore, *P. Brutia*, Ten., and with other synonyms, not to be confounded with that other *P. Pyrenaica* which is a form of *P. Laricio*. This species is so closely allied to the last that it is often considered a variety of it. But the leaves are stouter, the more numerous ducts are surrounded by strengthening cells, which are very scarce in the leaves of the other; in both, these cells are found near the vessels; the male flowers are twice as large; the outer pair of involucral bracts is almost equal to the inner ones; the cones are nearly sessile and thicker, generally several together, and often lateral and terminal on the same tree (see p. 171); the densely clustered cones in Tenore's typical specimen in the botanic garden of Naples are the result of disease.

16. *P. leiophylla*, Schiede & Deppe, has often 6 and even 7 leaves; the ducts are very small and often wanting; the strengthening cells, usually well developed in bundles under the epidermis, are, as well as the ducts, absent in Gregg's No. 821 from Zamora; the sheaths are usually deciduous, but scarcely so in Hartweg's No. 441.

17. *P. filifolia*, Lindl. In a specimen cultivated in Kew gardens the ducts are sometimes internal.

18. *P. Montezumæ*, Lamb., is, if I understand it correctly, a most variable species, the largest suit of different forms of which is preserved in the Berlin herbarium; some forms have longer, others shorter leaves, or stouter or more slender ones, 3, 4 or 5 in a bundle; cones long cylindrical or oval or conical; the scales in the typical form are depressed and regularly rhomboidal, in other forms they become strongly umbonate. It is quite diffi-

cult, therefore, to properly circumscribe the species; for the present I feel obliged to unite with it even *P. Hartwegii* and a number of others already included by Parlatore. Only a closer study on the Mexican mountains will decide whether or not several well characterized species may be hidden among them. All those that I could examine have numerous and strong bundles of strengthening cells under the epidermis and also near the vessels, but none around the ducts.

19. *P. Torreyana*, Parry, has the same structure of the leaves. The name was published in the Botany of the Mexican Boundary, 1859, and is therefore older than *P. lophosperma*, Lindl. of 1860.

20. *P. Arizonica*, Engelm. in Bot. Wheeler, p. 260, has also this structure and is thus distinguished from *P. ponderosa*, besides being five-leaved.

21. *P. Engelmanni*, Carrière, Conif. p. 356: *P. macrophylla*, Engelm. in Wisliz. Mem. p. 103, note 25, is a tree only known from Wislizenus' single specimen gathered in 1846 on the mountains of Cosiquiriachi, west of Chihuahua, where it is said to be abundant. The name was changed by Carrière because it clashed with Lindley's prior one; this, however, is considered by Parlatore to be a form of *Montezumæ*, but which I have not been able to examine. Our plant differs from this species by having its very stout leaves in threes and fours and very rarely in fives, in the strongly developed strengthening cells under the epidermis and also around the ducts, and inthe form of the cone. Parlatore does not mention it.

22. *P. ponderosa*, Douglas, a variable and wide-spread species of Western North America, several forms of which have been described as distinct. The only one which may perhaps claim specific recognition is our var. *Jeffreyi* (*P. Jeffreyi*, Murr.), characterized by its darker more finely cleft bark, glaucous branchlets, paler foliage, and much larger cones, with rather slender sharp recurved prickles and larger seeds; but it seems that intermediate forms unite it with the typical one. Another form which deserves notice is var. *scopulorum*, of the Rocky Mountains, with shorter and often binate leaves and smaller cones (see Engelm. in Fl. Calif. 2, p. 125).

23. *P. Canariensis*, Ch. Smith, is perhaps more nearly related to *P. Laricio* than to *ponderosa*. The articulation of the 4 involucral bracts is a curious feature which it has in common with our *P. resinosa* (see p. 168).

24. *P. Chihuahuana*, Engelm., first described from the mountains of Chihuahua, but now repeatedly found in Arizona, is well distinguished from all its relatives by its deciduous sheaths.

25. *P. Laricio*, Poir. Strengthening cells around ducts and in bundles all around leaf: the typical form has slender leaves and is tender in cultivation. Var. *Monspeliensis* or *Pyrenaica* (not to be confounded with No. 15, as the author of that species himself and many later botanists have done) has slender leaves with scarcely any strengthening cells around the leaf, and is more hardy than the species. Var. *Austriaca* or *nigra* is perfectly hardy; it has the stoutest leaves of all the forms, with abundant strengthening cells. A specimen in Herb. Kew, Birmah, Griffith 4993, may belong here, thus extending the range of the species far into Asia.

26. *P. Thunbergii*, Parlat. This is *P. Massoniana*, Sieb. & Zucc., and of many authors and many gardens, but is easily distinguished by its stouter, shorter leaves with parenchymatous ducts. It seems peculiar to Japan, though cultivated in Australia, whence *P. Australasiaca*, Steud., an original specimen of which I have been able to examine in Herb. Cosson. Its parenchymatous ducts distinguish this species at once from any other Japanese pine and place it near *P. Laricio*.

27. *P. contorta*, Dougl., is a little out of place here and evidently belongs nearer to the next group, but it has the subterminal cones of this. Like its American allies it is destitute of strengthening cells about the ducts, which character distinguishes it at once from its Old World associates, and so do the subulate points of the female scales. The low-growing narrow-leaved coast form, which is found along the Pacific from Northern California to Alaska is the original *P. contorta*, Douglas (from the mouth of the Columbia river) and *P. Bolanderi*, Parlat. (from Mendocino, California); it is a regular seaside tree, an excellent screen against the Pacific storms and their salt spray, just as *P. Halepensis* is on the Mediterranean; its leaves are often entirely destitute of ducts. The broader-leaved mountain form is *P. Murrayana*, Murr., as Jeffrey's original specimens prove, which come from the sierras; *P. muricata*, with which Parlatore unites it, is very different and belongs to the coast region; this broad-leaved form extends to Oregon and to the Rocky Mountains. While the forms of the coast and of the Rocky Mountains have very knobby, oblique, serotinous, and persistent cones (see p. 172), those of the sierras have occasionally more regular, less tuberculated, readily opening and deciduous cones, without being otherwise distinguishable (*C. S. Sargent*). The wood of this species is white and soft, and the tree is therefore often called white pine or spruce-pine.

28. *P. Sabiniana*, Dougl. and *P. Coulteri*, Don (*macrocarpa, Lindl.*) cannot be confounded by those that have been able to compare both growing; both have very large cones with spurred apophyses and large edible seeds, but the cones of *Sabiniana* are shorter, thicker, dark mahogany-brown; the seeds larger, 9–12 lines long, almost cylindrical, with much shorter wings; those of *P. Coulteri* are more slender, of a paler leather color, the seeds shorter, 6–8 lines long, and their wings longer. *P. Sabiniana* makes a round-topped tree with spreading branches and looser, more slender and lighter foliage on glaucous branchlets; *P. Coulteri* is a more conical tree with rigid brown-green branches and denser, coarser and darker foliage. The seeds of *P. Sabiniana* are or have been a most important article of subsistence for the Indians.

29. *P. insignis*, Dougl., distinguished by its fresh green foliage and closely and strongly serrulate leaves. Cones generally thick and very oblique, with the scales of the outer side large and thick, and on the inner side smaller and flat; some cones are more regular, all the scales nearly equally flat. For the synonymy I refer to Flor. Calif. 2, 127, repeating here only that the original *P. tuberculata*, Don, is founded on an unusu-

ally slender cone of this, and that *P. Sinclairii*, Hook. & Arnott, is a factitious species compounded of a cone of this and a branch of *P. Montezumæ*. The old and evidently erroneously described *P. Californiana*. Lois., is probably our species, but cannot now be identified.

30. *P. tuberculata*, Gordon Pinet. ed. 1, 211, not Don, a name at first erroneously given to a species sent by Jeffrey, is to be retained as now in general use and because Don's original *tuberculata* is a mere form of *insignis*. *P. Californica*, Hartw., is the same. It is the smallest pine known as a tree, fruiting often when only 2 to 3 feet high and rarely ever exceeding 15 or 18 feet. (See Engelm. in Flor. Calif. 2, 128.)

31. *P. Tæda*, Lin., and *P. rigida*, Mill., have sometimes, besides the regular parenchymatous, smaller, accessory internal ducts, thus approaching the *Australes* group. The cones are of a pale brown color, mostly very spinous, and very rarely serotinous. It is confined to the wet or sandy lower districts along the coast from Delaware to Eastern Texas. The most inland localities may be the Stone Mountain near Atlanta, Georgia, and Camden in Arkansas.

32. *P. rigida* var. *serotina*, *P. serotina*, Michx., I cannot distinguish specifically from *rigida*: it is more apt to grow on wet places (whence the name *Pond-pine*) and has longer leaves (occasionally, on strong shoots, in fours), and the cones often do remain closed for several years, as is also sometimes found in the northern *P. rigida*. The typical subglobose form of the cones which Michaux figures in his Sylva is quite peculiar, but only found in the coast region of South Carolina, from whence Dr. Mellichamp sends them; further inland the cones are more elongated, often twice as long as in the northern *rigida* (Wm. H. Ravenel, Aiken, S. C.) Prof. Sargent observed it on the Georgia and East Florida coast, but not in West Florida or in Alabama. Felled trees or posts set in the ground sometimes make sprouts bearing primary leaves.

33. *P. patula*, Schiede & Deppe. The epidermis cells of the leaves protrude so that the surface appears minutely tuberculate.

34. *P. inops*, var. *clausa*, was discovered and named by Dr. Chapman at Apalachicola, Florida, and Prof. Sargent finds it quite common on Cedar Keys. It is distinguished from the species by decidedly narrower leaves and by its cones being often serotinous, more in one tree than in another. The leaves are ½ line wide, while in the species they are often ¾ and even nearly 1 line wide; the sheaths in both forms are at last deciduous; young branches green, in the northern form glaucous; involucrum of 10 to 11, in *inops* of 8 to 9 bracts; cones larger, mostly subsessile, recurved; in the other, mostly longer peduncled and patulous; cotyledons fewer, 4 or rarely 5, in the other 5 or 6.

35. *P. pungens*, Michx. Leaves rarely in threes and sometimes with accessory internal ducts. The cones persist sometimes 20 years or longer.

36. *P. muricata*, Don. Male flowers only ½ inch long in a spike of about 1 inch in length, similar to those of *tuberculata* and *insignis:* antheral crest strongly denticulate, in the others nearly entire. Specimens

have been collected at Tomales Point with subterminal cones, not different in any other respect. The cones of the southern specimens (from Monterey, etc.) have usually very long, $^1_2$ inch, and stout curved spurs, especially on the outer side, and fully deserve their specific name, but others from farther north (Mendocino, etc.) are more regular, with short and thin, though very sharp, prickles.

37. *P. Pinaster*, Ait. The male flowers form a large oval head; involucral bracts often only 3 or sometimes 4, all of equal length. Geographically and structurally this species is more nearly allied with *P. Canariensis*, less so with *Laricio*, but is distinguished from both by the lateral (quite rarely subterminal) female ament.

38. *P. mitis*, Michx. Wide-spread through the middle and partly the southern States, rare in New Jersey and not now found farther north; westward to Arkansas and to Missouri south of the Missouri river, where it is the only species of pine: it is found always on silicious soil: it furnishes excellent "hard pine" lumber. The outer pair of the 9–12 involucral bracts is scarcely half as long as the inner ones.

39. *P. glabra*, Walt. Similar to the last, with slender foliage, smoother bark (in young trees and on the branches the grayish bark is quite smooth) and almost unarmed cones, distinguished by Walter 100 years ago, but long overlooked, until W. H. Ravenel, about 25 years since, rediscovered it. Dr. Mellichamp finds it scattered on the coast of South Carolina, where it grows on the edge of or in swamps, and on the knolls in them, with *Magnolia*, *Fagus*, and *Nyssa*: rarely on sandy soil, and never in the so called Pine-barrens. He describes the branching of the tree as singularly characteristic, the spray usually being flattened somewhat like that of Cedrus. It probably extends through the lower parts of the southeastern and southern States, as it is again found in Mississippi (E. Hilgard). The tree (known in South Carolina as the *Spruce-pine*) grows up to 80 feet in height; the gray bark of such old trees is flakey and is compared by some to that of the sugar-maple, by others to a smoothish white-oak bark. The leaves are usually $2\frac{1}{2}$ to 3 inches long, not half as thick as they are wide, while in *P. mitis* their thickness exceeds half their width; the external involucral bracts are minute.

40. *P. Banksiana*, Lamb., published 1803 in Lambert's first edition, a year prior to Poiret's name of *P. rupestris*, which name, erroneously preferred by Parlatore, must give way to the former. Probably the only pine with erect or at least patulous cones; the small prickles of the very young cones soon disappear, so that the mature ones are unarmed. The base of the wing entirely covers the outer side of the seed and separates from it, just as it does in *Picea*, and which I have not seen in any other pine to this extent. The cones are often serotinous and persist for a long time. The seeds seem to germinate most readily, just like those of *P. Tæda*, and in moist sandy soil, in old fields and along railroads young trees spring up abundantly. It makes a moderate sized tree, but is perhaps never over 20 or 30 feet high, and 10–12 or very rarely 18 inches in diameter. Very

common in Northern Michigan and Wisconsin, it does not seem to extend farther westward than the Saskatchawan, where it is replaced by *P. contorta*.

41. *P. oocarpa*. Schiede. Most of the ducts are internal; occasionally a parenchymatous one was found in the leaves examined by me. Further investigation must show whether this species may not more properly be referred to its Mexican neighbors of the *Pseudo-Strobi* group. Strengthening cells are abundant around, under the epidermis and also near the vessels.

42. *P. australis*. Michx. Male flowers 2½–3 inches long, the longest of any pine, of rose-purple color; lowest pair of involucral bracts minute. On a very vigorous shoot I have seen the female ament lateral (see p. 170), a rare anomaly. In the germinating plantlet, the long wing remaining attached to the seed shell is raised up like a flag by the growing cotyledonous leaves.

43. *P. Elliottii*. Engelm. For a full account see below.

44. *P. Cubensis*. Griseb. Leaves in threes, only exceptionally in twos, 8–10 inches long, rarely longer, stout, about ¾ line wide, rigid, strengthening cells largely developed under the epidermis (so that their bundles sometimes extend from the epidermis to the ducts) and also near the vessels; bracts 3–3½ lines long, strongly fringed, reflexed, rather persistent; male flowers about 1½ inches long; involucral bracts 13-15, the outer pair half as long as the inner ones; anther-crests scarcely denticulate; cones 2½–3 inches long, short-peduncled, scales depressed; seeds 3½ lines long, faintly ridged; wing nearly twice as long, widest at base, tapering to an acutish point. The var. *tertrocarpa*, Wright, in Gris. Cat. Cub. 217, is a very curious form but not a variety. It seems that in this case the growth of the axis is entirely arrested after producing an ament, and does not even elongate in the following season: the maturing cone, therefore, remains erect near the top of the branch. I have seen an analogous arrest of growth in the biennially-maturing *Quercus chrysolepis*. It is found in different parts of Cuba, in the maritime districts as well as on the mountains, and is probably the same that gives the name to the Isle of Pines. A cone from the Bahama Islands, preserved in the Kew Museum under the name of *P. Tæda*, probably also belongs here.

45. *P. Wrightii*. Engelm. n. sp. Leaves in twos, very rarely in threes, slender, 5 to 8 inches long, ½ line or less wide; sheaths 4 lines long, with age a little shorter; bracts small (1½ lines long), very slightly fringed and rather deciduous: cones lateral, peduncled, recurved, oval, 1½ to 2½ inches long, scales radiately grooved, thickened on the crenulated edge, apophyses retused, umbo immersed, prickles short; seeds 2½ lines long, faintly ridged, wings (perhaps incomplete?) not much longer, widest above the base. — Mountains in Eastern Cuba, apparently mixed with the last. Chs. Wright No. 1462 in part, 3190. Distinguished from the allied *P. Cubensis* by its slender binate leaves, short, scarcely fringed deciduous bracts and smaller cones and seeds. I have not seen the male flowers. The cone-scales of both species are arranged in the $\frac{2}{13}$ order, the 8 and 13 spirals being the most prominent.

## Pinus Elliottii, Engelm. n. sp.

A large tree, 50–100, rarely to 110 feet high, 2–4 feet in diameter, with (7–15 lines thick) laminated, reddish-brown bark; leaves in twos and threes, in the axils of lanceolate, long-fringed, somewhat persistent bracts, 7 to 12 (mostly about 9) inches long, $\frac{3}{4}$ to nearly 1 line wide, rigid, closely serrulate, acutish; sheaths at first about $\frac{3}{4}$ inch long, later withering to one-half that length; resin ducts internal (adjacent to the sheath of the vascular bundles). Male flowers from the axils of similar, persistent bracts, cylindrical, elongated ($1\frac{1}{2}$ to 2 inches long), in a short head (not more than 1 inch long), each one surrounded by an involucre, 4 lines in length, of about 12 bracts, the exterior pair strongly keeled, half the length of the inner ones; anthers with semicircular, denticulate, rose-purple crests; pollen grains 0.037 to 0.045, on an average 0.04 lines in the longer diameter. Female aments peduncled, mostly 2 to 4, or rarely to 6 together, oval, purplish, at first erect, but soon assuming a horizontal and (a month later, and before the leaves are well developed) a recurved position, the axis meanwhile elongating and in vigorous trees not rarely forming a second tier of aments several inches above the first ones; the bracts above the aments bear the usual leaf-bundles, so that no naked space is left; carpellary scales broad, rounded, more or less abruptly cuspidate, their bracts half their length, transverse, retuse. Cones peduncled, recurved, oval to cylindrico-conical, 3 to $6\frac{1}{2}$, usually 4 to 5 inches long, $1\frac{3}{4}$ to $2\frac{1}{4}$ inches in diameter (when closed), of a rich brown color and almost glossy; bracts thickened, retuse, or emarginate; scales in $\frac{13}{21}$ order, the 5 and 8 spirals most conspicuous; larger scales 2 inches long and 7 lines wide; apophyses marked with grooves, radiating from the slightly prominent umbo, transversely divided by a sharp ridge, armed with a short stout or rarely a slender sharp prickle. Seeds triangular, $2\frac{1}{2}$ to $3\frac{1}{2}$ lines long, dark, slightly ridged, and rough on the under side; wing 4 or 5 times as long (13 to 16 lines long), somewhat oblique, obtuse, with nearly parallel sides, or usually somewhat broader below, its base covering the greater part of the outer or upper surface of the seed; cotyledons 6 to 9, usually 8.—*P. Tæda*, var. *heterophylla*, Elliott. Sketch 2, p. 636.

Common, in light sandy damp soil, among the sandhills near the seabeach and along the marshes near the mouths of rivers;

also found in damp clayey pine lands and with *P. rigida*, var. *serotina*, in pine-barren ponds, rarely exclusively covering small tracts, and only as a second growth in old fields. From South Carolina, on the sea islands near Charleston, to Georgia along the coast, and sparingly as far as 15 to 20 miles inland, but never very far from the influence of salt water, *Dr. Mellichamp*; to Georgia, *Elliott*; and Florida, *Canby*, *Curtiss*; forming forests on the St. John's river, where it is often called *Slush-pine*, and is not cut for timber, *Sargent*; "the most common pine in South Florida, the 'short-straw pine' of the wood-cutters, taller, more slender, and with harder wood than the 'long-straw pine,' *P. australis*, which is the principal forest tree of Eastern, Middle and Northern Florida," *Dr. A. P. Garber*; extending westward to Alabama, "a common tree along the bay of Mobile," *Mohr*, *Sargent*. Prof. Sargent observes that while the long-leaf pine rapidly disappears under the axe, Elliott's pine becomes more and more common, the young second growth forests in Florida almost entirely consisting of this species and of *Taeda*.

This is the earliest flowering pine of those regions, from 2 to 4 weeks in advance of any other pine, showing its rose-purple male flower-buds already in December, and in January or February, according to latitude and season, shedding its abundant pollen, which, wafted by the winds, is apt to cover roads and streets, and especially sheets and pools of water, far and wide, with its sulphur-looking powder. *P. australis*, also with rose-purple flowers, comes several weeks later, and then the others, *P. Taeda*, next *P. glabra* and *mitis*, and lastly *P. rigida* var. *serotina* with greenish-yellow flowers. Our species bears abundantly every year (at least in South Carolina), different from *P. australis*, which, like many other pines, is fruitful only every other season. The cones also mature and drop off earlier than those of the associated pines, and shed an abundance of seeds, which readily germinate about November, and develope their young stems in spring.

This tree Prof. Sargent considers by far the handsomest of all the southern pines, readily distinguished from those, with which it is associated, by its heavier, denser heads, darker foliage, and larger and heavier branches.

The red-brown bark is very characteristic of this species; it is

regularly laminated, and the outer lamina exfoliate in rather rigid and brittle, often very thin, plates of a purplish color when fresh, whence the local name of *Blue-pine*: the bark of *P. australis* is somewhat similar, but the plates are much larger.

The timber is excellent, heavy, very tough, and more resinous even than that of *P australis*, which it resembles: of a striped yellowish-brown and paler resin color (the inner portion of each ring, formed earlier in the season, being paler: the outer part, of later growth, brown): fibre coarser than in *australis* and more tenacious. It grows rapidly, at least in its youth: a tree of 22 inches diameter, and about 140 years old, had in the semi-diameter 8½ inches of heartwood with 74 annual rings, and white sapwood 2½ inches thick with 60 to 70 rings; another of over 3 feet diameter, 109 feet high, and 200 years old, had a radius of 17 inches heartwood with about 140 rings, and 3 inches of sapwood of 60 rings. Thus the average rings of the heartwood were over 1⅓ lines and those of the sapwood (because of later growth) about ½ line wide. The leaves of young trees are more frequently in twos, in older ones as often in threes; those of trees from swampy soil are apt to be shorter than others; the structure in all of them is the same.

Our species is closely allied to *P. Cubensis* (see p. 185), and further study of the latter may possibly prove them to be nothing but geographical varieties. Meanwhile the constantly three-leaved foliage, the larger number of involucral bracts of the smaller male flowers, the smaller cones with smaller, shorter-winged seeds, distinguish *P. Cubensis* from our species. Of the bark, of the timber, or of the behaviour of the young cones in this species we know nothing.

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*P. Elliottii* was imperfectly known to Elliott, and was considered by him a form of *P. Taeda*. Later botanists ignored it till Dr. J. H. Mellichamp of Bluffton, S. Car., rediscovered it about ten years ago and directed my attention to it. Without his diligent investigations, ample information, and copious specimens, this paper could not have been written. At the same time I gratefully acknowledge my obligations to many botanical friends in this country and in Europe, and especially to the directors of the

botanical gardens and the curators or possessors of the great herbaria, who most liberally furnished me with the material to carry on my investigations of the Pines and of the Conifers in general. I am particularly indebted to Messrs. Bolander, Brewer, Parry and Lemmon for their contributions of the Californian and Rocky Mountain Conifers, and to Messrs. Canby, Gilman, Ravenel and Mellichamp for those of the northern and eastern American Pines.

## EXPLANATION OF FIGURES.

Pl. I. fig. 1. A branch, gathered in September, showing two mature cones, of the preceding years, flowering, and three young ones of the spring. One-half nat. size.

fig. 2. Leaves in twos and threes. Nat. size.

fig. 3. Their close serratures. Magn. 60 times.

figs. 4-7. Sections of leaves magnified 30 times, 4 and 5 of binate, 6 and 7 of ternate leaves; the ducts are seen closely appressed to the sheath which encloses the vascular bundles; these bundles are, as in most pines, double, and either separate or closely approximate and almost united; the ducts are wide or small, few or many, in these specimens, varying from 4 to 9.

Pl. II. fig. 8. Male inflorescence, capitate, with the elongated flowers in the axils of fringed bracts.

Pl. I. fig. 9. One of the flowers, magn. 3 times, exhibiting the calycoid involucrum.

Pl. II. fig. 10. A bract, and

fig. 11. The involucrum from the dorsal, and fig. 12 from the ventral side, exhibiting the lowest lateral pair of bracts and the succeeding inner and upper ones. Magn. 4 times.

Pl. I. fig. 13. Diagram of the involucrum with the supporting bract; the 2 outer scales are strongly, the 4 next ones slightly, keeled.

fig. 14 and 10 bis. Effete anther from above and the side, showing the transverse erect crest and one of the longitudinally opened cells. Magn. 10 times.

Pl. II. fig. 15. Female aments in bloom, the axis above them already elongating.

fig. 16. The same, a little more advanced.

fig. 17. An ament magnified twice.

fig. 18. A female flower (carpel scale) in the axil of the broad retuse bract — only the upper, cuspidate, half being visible, and below the bifid tips of the (rather clumsily executed) ovules—in February. Magn. 10 times.

fig. 19. Female aments, six weeks or two months later, recurved.

Pl. I. fig. 20. One of these, magnified.

Pl. III. figs. 21-24. Closed cones of different sizes and shapes, showing their variability.

fig. 25. Base of an open cone with spreading scales.

figs. 26, 27, 28. Scales of a cone. Fig. 26, dorsal view, showing the bract and the apophysis; fig. 27, view from above, exhibiting the impression made by the seed and the surface from which the wing had become detached; fig. 28, section of a scale with the seed (exhibiting the embryo) and wing.

fig. 29. Seeds from the lower, and fig. 30 from the upper side, with differently shaped wings; in fig. 29, the rough under surface of the seed is seen; fig. 30 shows its upper surface partly denuded of the wing-covering.

figs. 31 and 32. Albumen and embryo of different shapes. Magn. 4 times.

Pl. I. fig. 33. A germinating seed in November.

fig. 34. A seedling of the following spring, exhibiting the 8 cotyledons, the primary leaves, and upwards already some pairs of secondary leaves.

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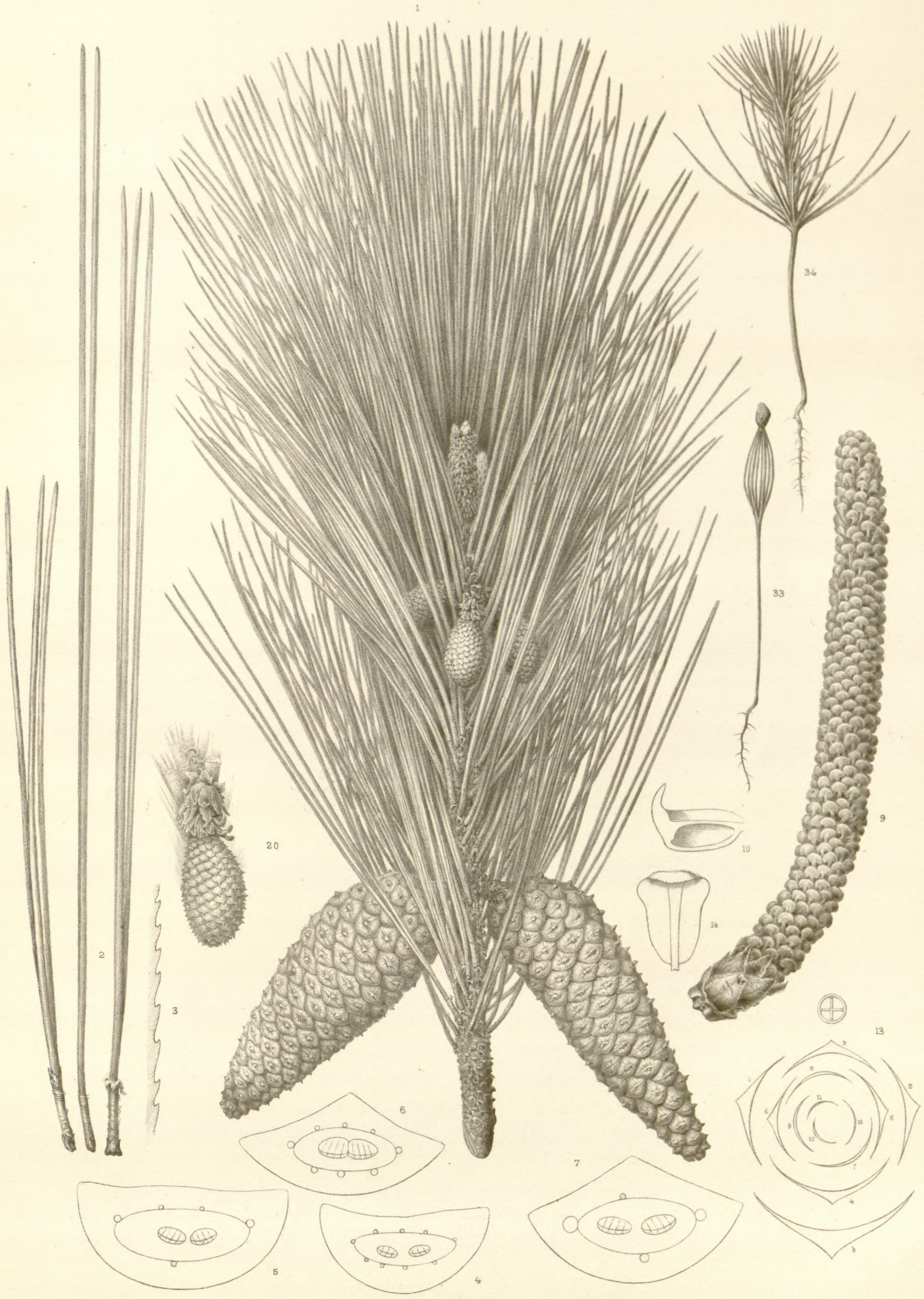
The plates were drawn on stone, from nature, by **Mr. Paulus Roetter, late** of St. Louis, who had made himself so favorably known, more than twenty years ago, by the beautiful Cactus plates published in the Report of the Mexican Boundary Commission, and who has since greatly added to his fame and his usefulness by his artistic work in the Zoological Institute in Cambridge.

## CORRECTIONS.

Page 173, l. 20, and p. 180, No. 13. A cone of *Pinus Gerardiana*, just received from the Kew Museum, shows that the wings of the seeds are as small as any, and that, curiously enough, at least in this specimen, they adhere, when the seeds drop out, to the back of the scale above the one to which they belong. The description of Lambert of the wing of the seed is therefore erroneous. The number of cotyledons is ten.

Page 187, l. 26. *Pinus Tæda* flowers immediately after *P. australis*, or almost together with it, in this spring, 1880, in South Carolina, in the first week of March.




PINUS ELLIOTTII, Engelm.

P.Roetter from nat.on stone.

Print.by A.Meisel

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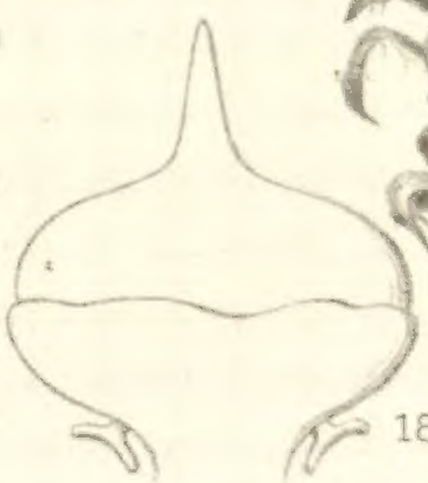

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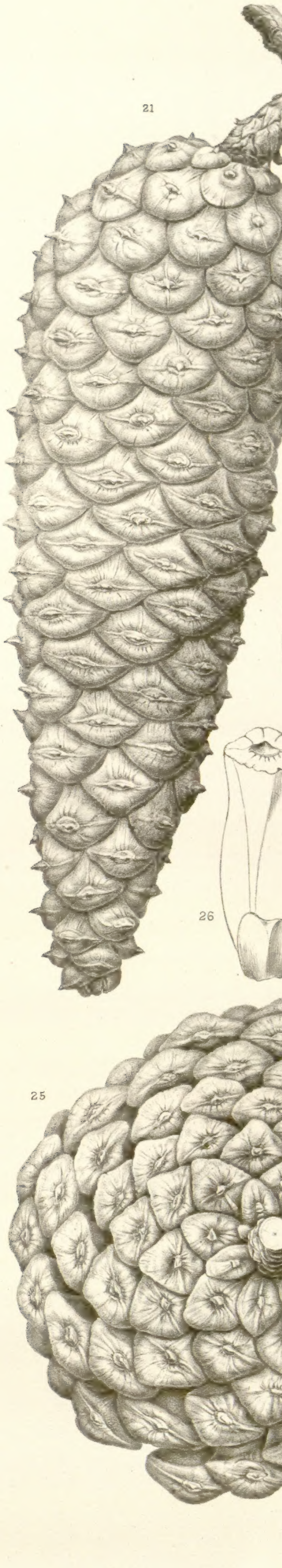
# PINUS ELLIOTTII, Engelm.

P. Roetter from nat. on stone.

Print. by A. Meisel



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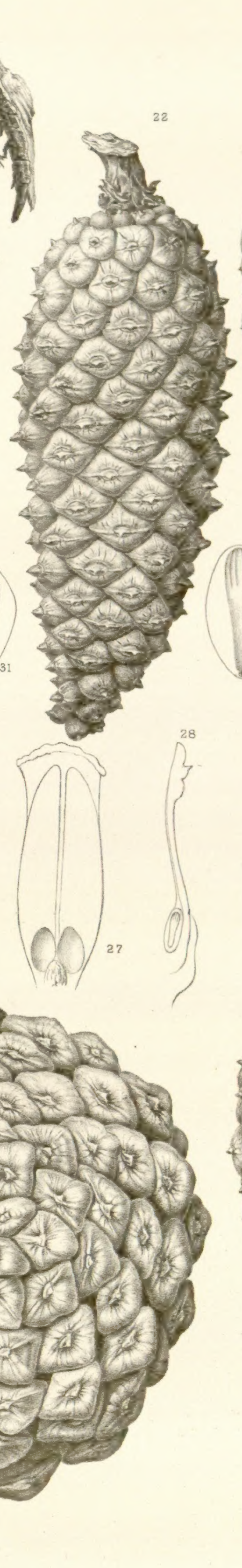

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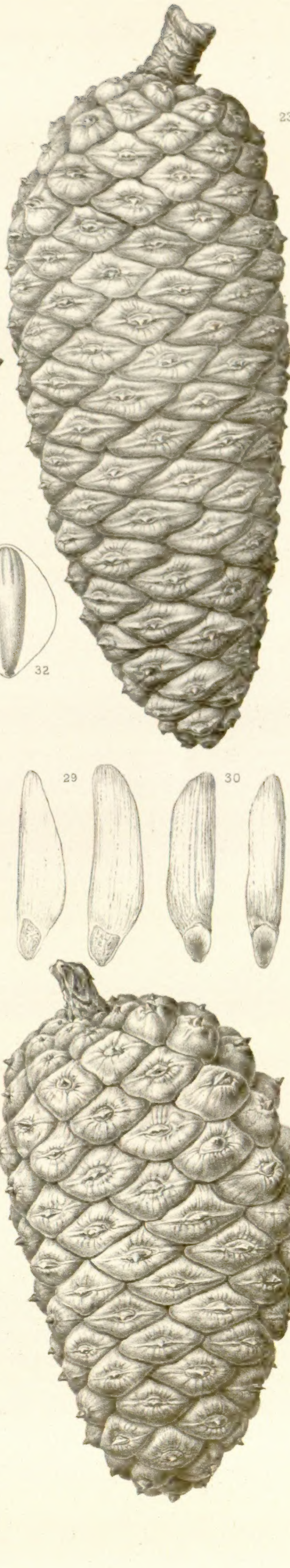

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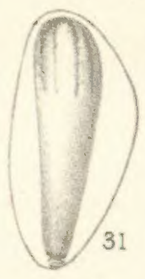

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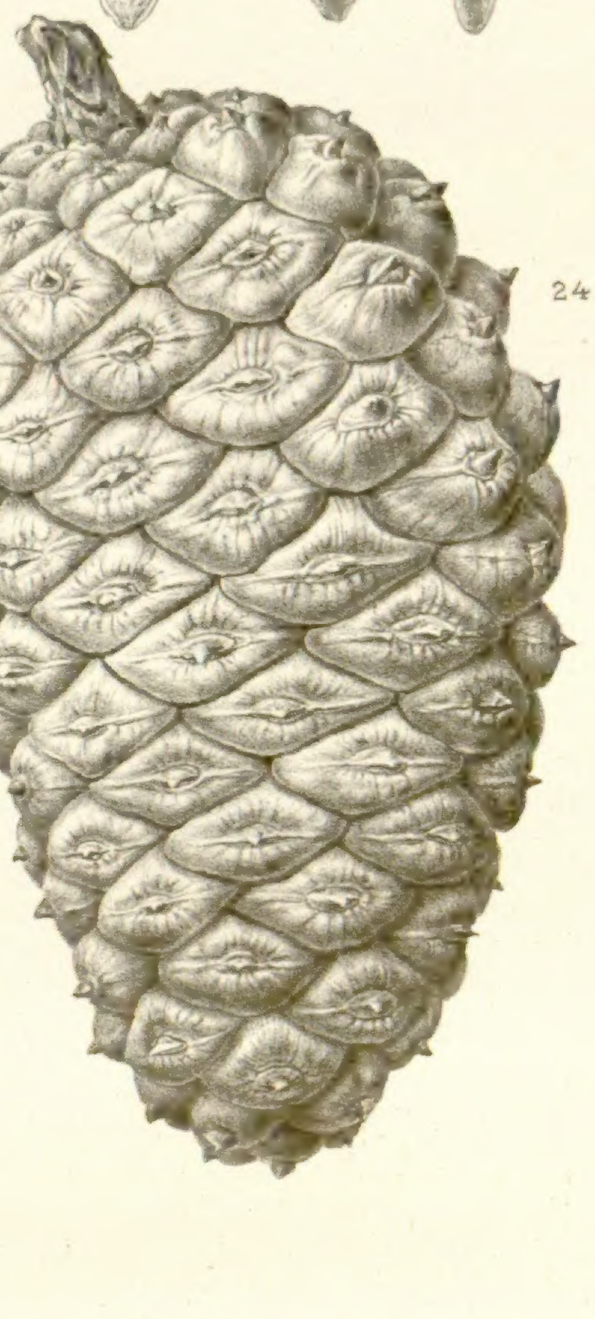

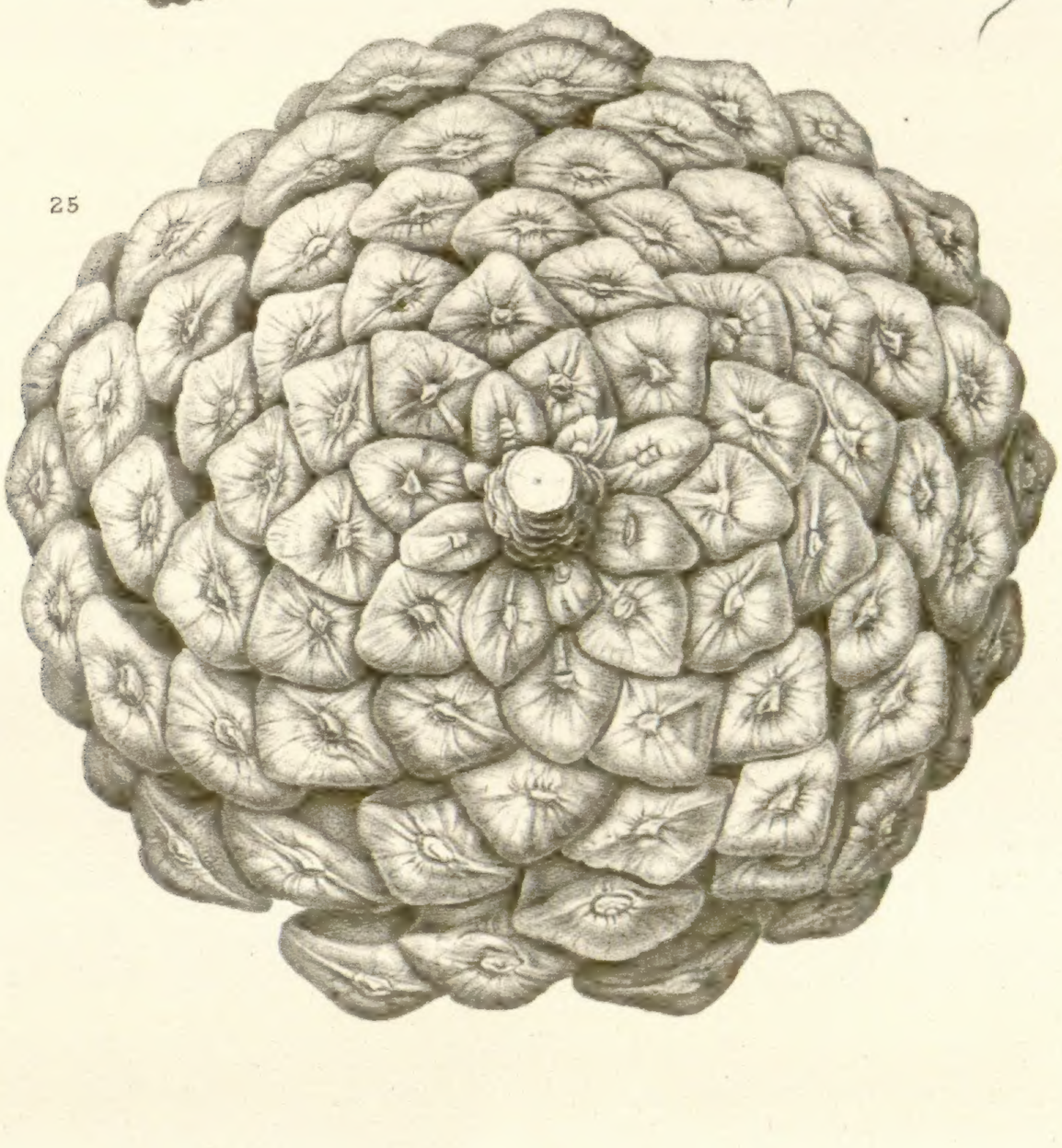

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PINUS ELLIOTTII, Engelm.

P. Roetter from nat. on stone.

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